An overview of CARRS-Q's advanced driving simulator

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Centre for Accident Research & Road Safety - Queensland

CARRS-Q is a joint venture initiative of the Motor Accident Insurance Commission and Queensland University of Technology

www.carrsq.qut.edu.au

Overview

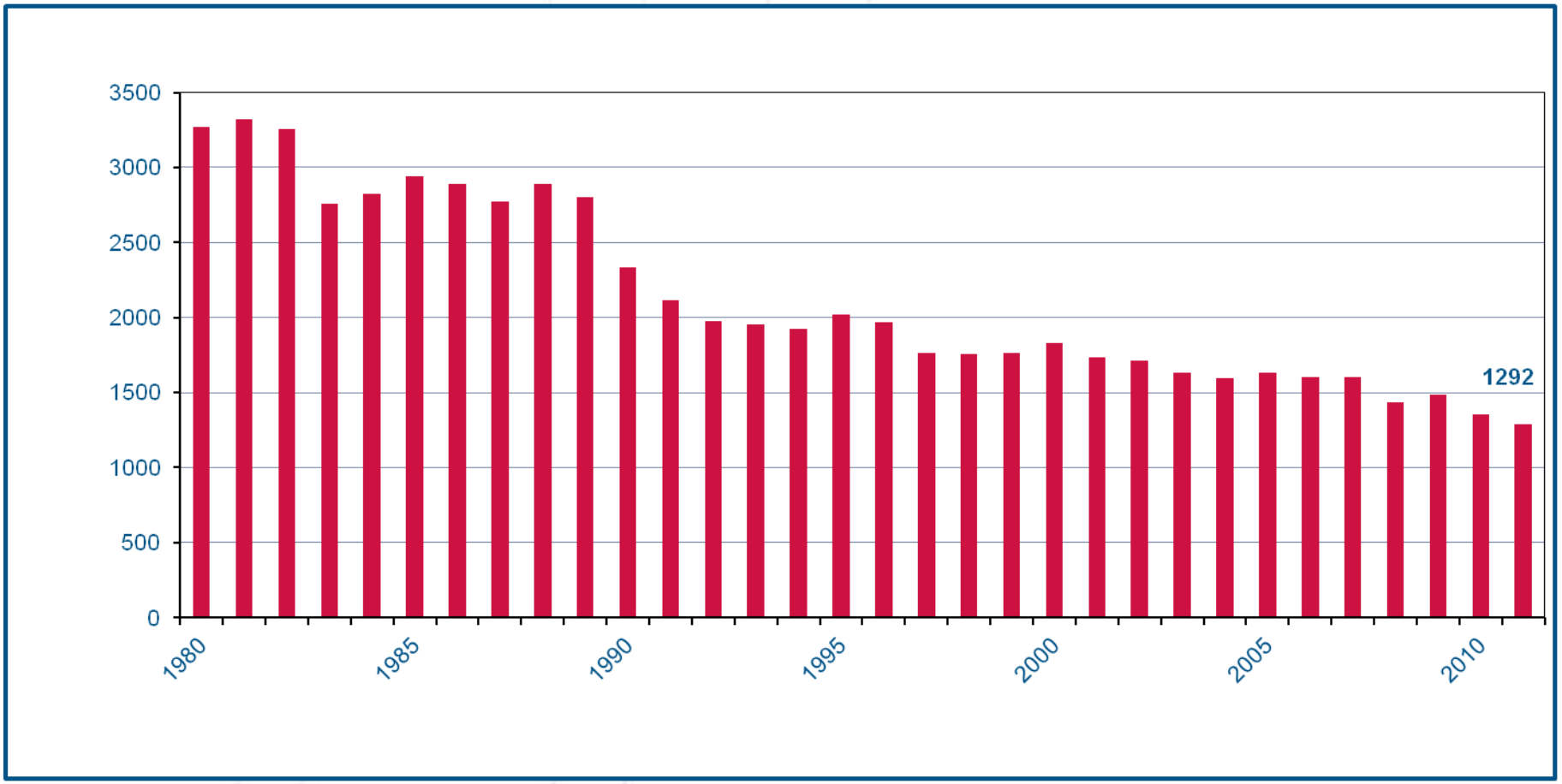
- The global road safety problem
- The role of human factors in road crashes
- The use of driving simulators in road safety research
- The CARRS-Q advanced driving simulator
  - Functionality
  - Problems encountered and related solutions
- Past and current projects using the driving simulator
- Limitations of driving simulators

Road safety: an international problem

- It is estimated that:
  - Worldwide, there are over 1 million fatalities and 50 million injuries from road crashes each year
  - Road fatalities account for 2.1% of all deaths and 23% of all injury deaths
  - Road crashes are currently the 11th leading cause of death, and are anticipated to become the 6th leading cause by 2020
  - There are over 100,000 road fatalities each year in China

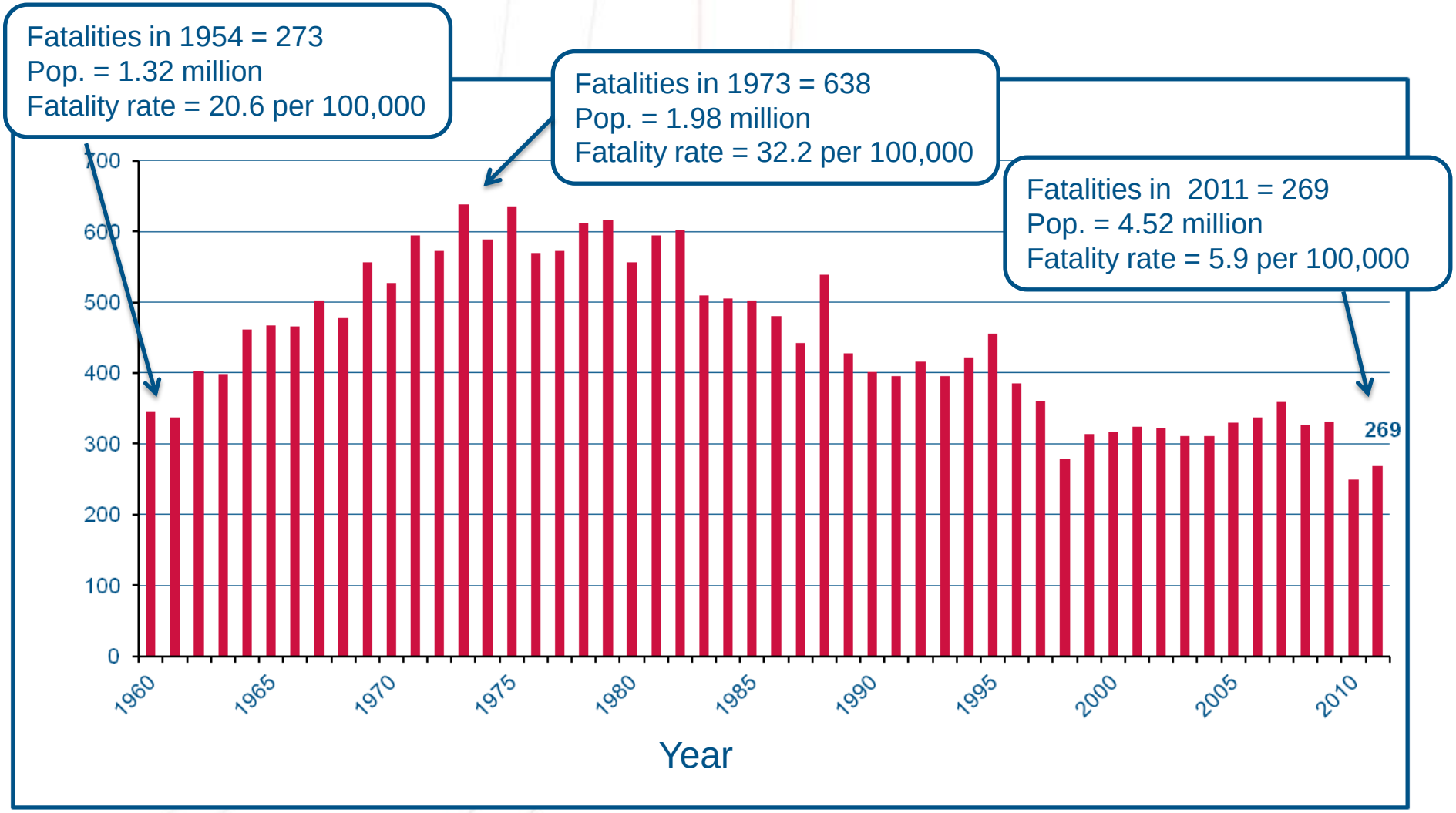
Sources: Peden *et al*, 2004; King, 2005

Australian road fatalities: 1980-2011

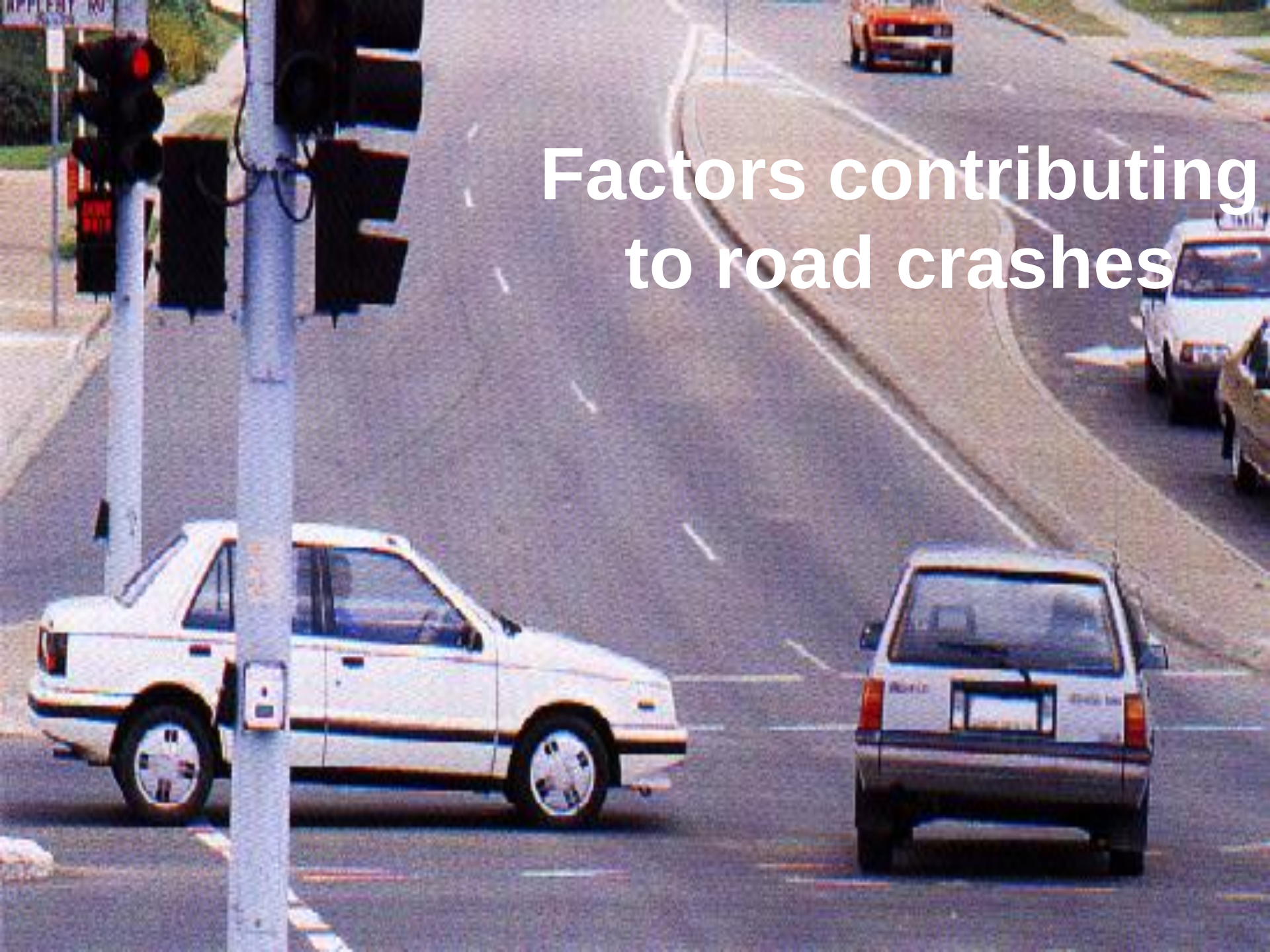


Source: BITR, 2012

Queensland road fatalities: 1954 - 2011



Sources: Queensland Transport, 2009; BITR, 2012

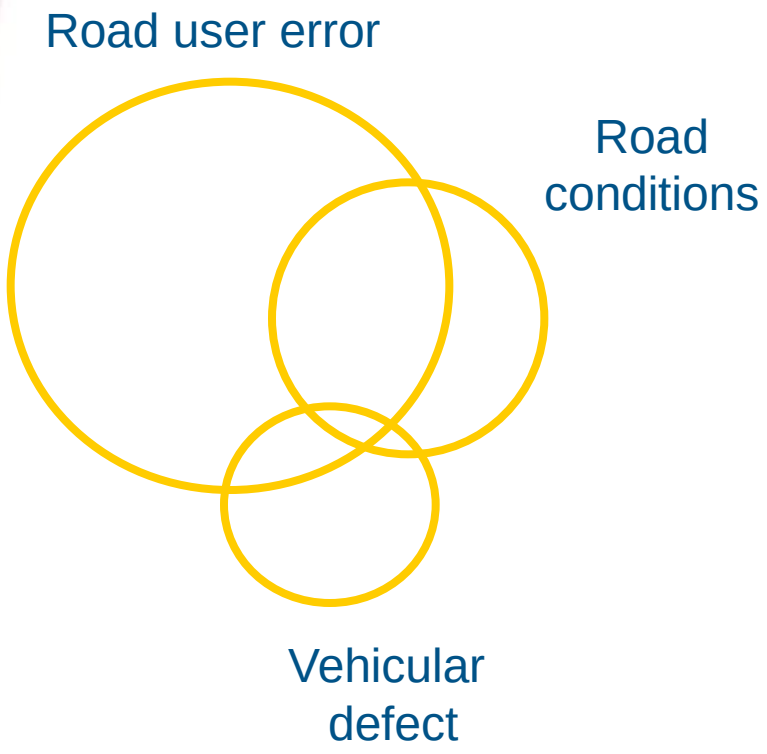


Factors contributing to road crashes

Crash causes

Rarely a single cause, but a ‘causal chain’ of events

- 90% road user error
- 30% road conditions
- 10% vehicular defect or failure



Source: Shinar, 1978

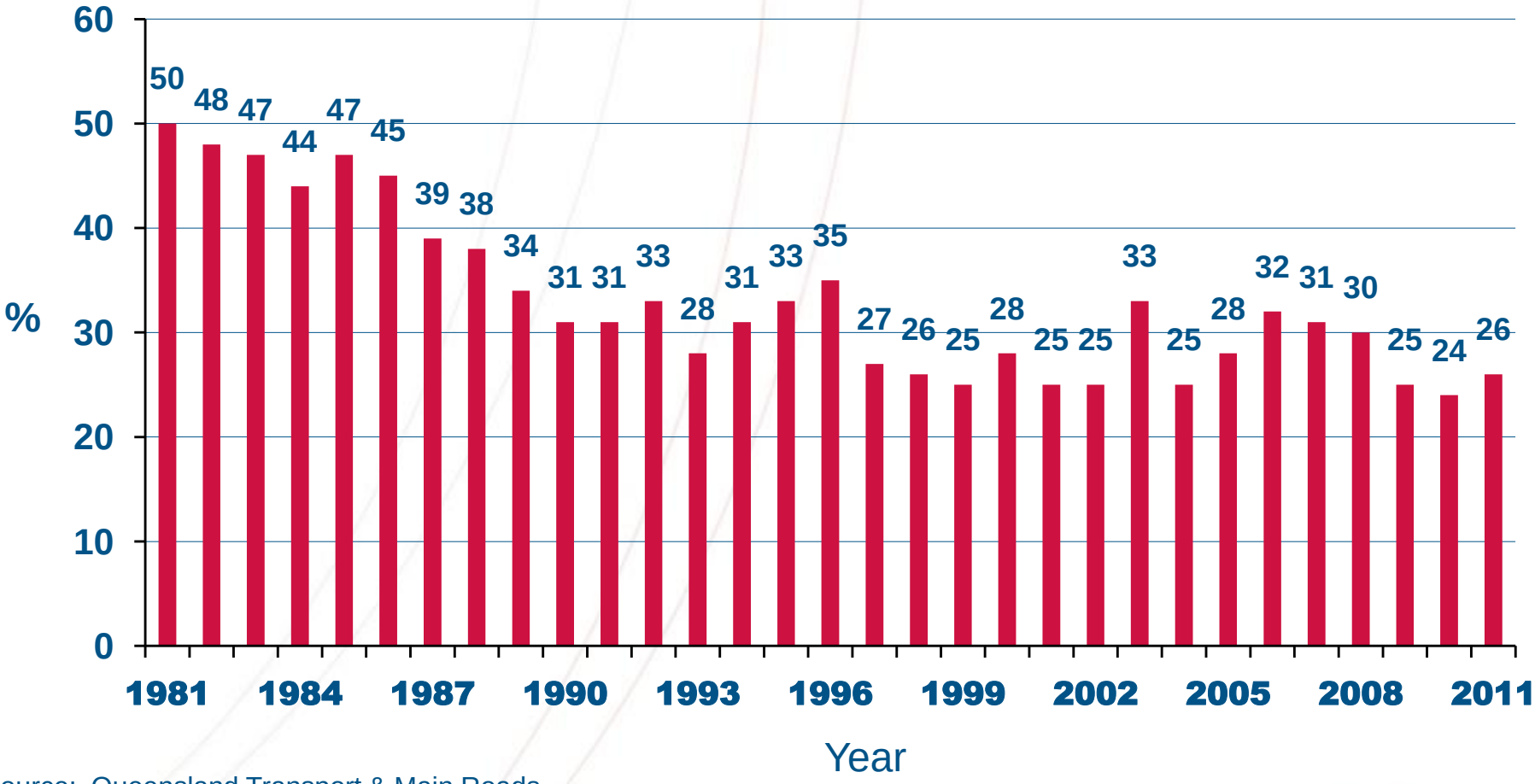
Contributing factors to crashes in Queensland: 2007

Factor	Fatal crashes (*n* = 338) *N*	Fatal crashes (*n* = 338) %	All crashes (*n* = 22832) *N*	All crashes (*n* = 22832) %
Alcohol / drugs	119	35.2%	2743	12.0%
Disobey road rules	105	31.1%	9775	42.8%
Inattention / distraction	96	28.4%	6600	28.9%
Speed	92	27.2%	1488	6.5%
Fatigue	59	17.5%	1239	5.4%
Inexperience	51	15.1%	4341	19.0%
Age (lack of perception)	25	7.4%	1164	5.1%
Rain / wet road	22	6.5%	2151	9.4%
Other driver conditions	17	5.0%	1319	5.8%
Negligence	15	4.4%	455	2.0%
Road conditions	11	3.3%	1332	5.8%
Vehicle defects	6	1.8%	690	3.0%
Other	243	71.9%	20663	90.5%

Note: More than one contributing factor could be attributed in a crash and hence factor totals do not reflect crash totals, and percentages sum to more than 100%

Source: Web Crash

Percentage of drivers and riders killed with BAC of .05 or more in Queensland: 1980-2011 (where BAC is known)



Source: Queensland Transport & Main Roads

Prevalence of drug driving

- Growing concern regarding the prevalence of drug driving and its impact on crash risk
- An Australian study found 26.7% of motorists killed had drugs other than alcohol in their system (Drummer *et al*, 2003)
- A Victorian roadside study found 2.4% of drivers tested positive for cannabis or amphetamines, which was twice the drink driving detection rate (Drummer *et al*., 2007)
- A Queensland roadside survey of 2657 drivers in metropolitan and regional centres found that 3.1% had a drug in their system with cannabis being the most common (Davey *et al*, 2009)
- Most Australian states have introduced Random Drug Testing for illicit drugs, but more needs to be known about the influence of illegal and prescription drugs on driver behaviour

The growing problem of driver distraction

- Growing international concern about the role of driver distraction in road crashes
- The combination of distraction and inattention is identified as a contributing factor in over 25% of fatal crashes in Queensland
- The use of mobile phones in any form is illegal for novice drivers in Australia
- The use of hand-held mobile phones are illegal for other drivers
- Despite this, the use of mobile phones (including texting) remains widespread in Australia
- Growing concern about other in-vehicle distractions including navigation systems and other advisory systems

Normal

Cataracts

Glaucoma

Age-related Maculopathy

Source: Wood, 2000

Driving simulators: A research tool

- Provide the computational capabilities and fidelity to create complex driving situations with varying task demands with high repeatability
- Can expose drivers to situations and conditions that would be logistically difficult on the road
- Enables research that would otherwise be unsafe or unethical in a real-world setting
- Can be used to study emerging safety issues
  - proactive & precise description of driving performance

The flexibility of driving simulators

- Immersive environment, fully interactive, including traffic, roadway environmental characteristics
- Provide the driver with high-fidelity motion, visual, auditory, and force feedback cues
- Can replicate a range of driving conditions: high/low density, urban/rural roads, different road surfaces….

Potential research applications of driving simulators (1)

- The impact on driver behaviour of impairment due to:
  - alcohol, illicit drugs, prescription drugs, fatigue
  - medical conditions eg. vision problems, physical disability
  - internal distractions eg. in car devices, passengers
  - external distractions eg. roadside advertising signs
- Interactions between different road users eg. cars and motorcycles, pedestrians and cars

Potential research applications of driving simulators (2)

- The influence of different external environments on driver behaviour:
  - road engineering (lane width, lane markings)
  - road infrastructure, such as railway crossing design
- The influence of different vehicular characteristics on driver behaviour:
  - personal communication devices
  - driver aids such as collision detection devices, intelligent speed adaptation
  - other ITS devices

CARRS-Q Advanced Driving Simulator (1)

- Complete vehicle body (Holden VE Calais) as the simulator cabin
  - full integration of vehicle controls and instruments
  - all five seats available for multiple occupant studies
- 180 degrees of forward vision
  - provided by three 4m by 3m forward screens and projected images
- Simulated rear vision in centre and two side mirrors
  - provided by replacing the mirrors with similar sized LCD screens
- Simulated motion in three dimensions
  - provided by a REXROTH 6 Degrees of Freedom motion system
  - provides up to 700mm of motion in each direction, and up to 39 degrees of rotation in each direction

CARRS-Q Advanced Driving Simulator (2)

- The CARRS-Q simulator can integrate three aspects of simulation:
  - driving simulator
  - traffic simulator (links to AIMSUN)
  - control simulator
- It uses research grade simulation software, SCANeR, produced by French company OKTAL
- Located in a purpose-fitted building with space for managing study participants
- Supported by a “Desktop” simulator running the same software, which assists with programming of driving scenarios

CARRS-Q Advanced Driving Simulator

View of the Advanced Driving Simulator from the Control Room

View into the Control Room

Other equipment used

- Eye tracker
- EEG, ECG, Skin conductance
- Body/head movements – accelerometers
- Head up display
- Data fusion algorithms to synchronize equipments

“Simulator Sickness” (1)

- Nausea induced by simulation is a well known issue
- The research literature, and our experience, shows peripheral vision and motion are major influences
  - more than about 140 degrees of forward vision are required for peripheral vision cues to indicate expected motion for most people
  - no participants have experienced nausea in our “desktop” simulator with about 50 degrees of forward vision (1.6m screen at 1.8m distance)
  - with the 180 degree front field of view of the Advanced Driving Simulator, operation without motion is possible, but is the most nauseating

“Simulator Sickness” (2)

- For the Advanced Driving Simulator, sharp corners (for example 90 degree bends) produce the greatest discrepancy between the seen and felt motions
- Responses vary greatly between individuals, but even with optimum tuning and subject screening approximately 10% of participants are experiencing sufficient nausea to abort simulation
- CARRS-Q has implemented a research protocol involving a brief pre-study questionnaire to identify those participants likely to experience ‘simulator sickness’

Managing research participants (1)

- Despite the realistic simulated environment, participants still require some time to adjust to the simulator and its characteristics:
  - steering wheel and brake pedal feel
  - accelerator and braking response
  - characteristics of the simulated vision and motion
- To address this, a "familiarisation" drive of around 5-10 minutes is generally included at the start of the session
- The “familiarisation” drive includes objects and activities that will be included in the research scenarios eg.
  - other road users (cars, pedestrians, cyclists etc)
  - driving activities, such as overtaking
  - road infrastructure (signage, traffic lights etc)

Managing research participants (2)

- Individual participants display a range of driving styles, from cautious to aggressive
- It can be challenging to design simulation scenarios that cope with a wide range of driving styles eg.
  - critical event setup that works well if the driver is following the speed limit may not work if the participant is driving too fast or too slow
- Multiple test drives of new simulation scenarios are desirable with associates unfamiliar with the research details
- There are very few instances of drivers not becoming immersed in the simulation and driving in a manner that they would not normally use

Managing research participants (3)

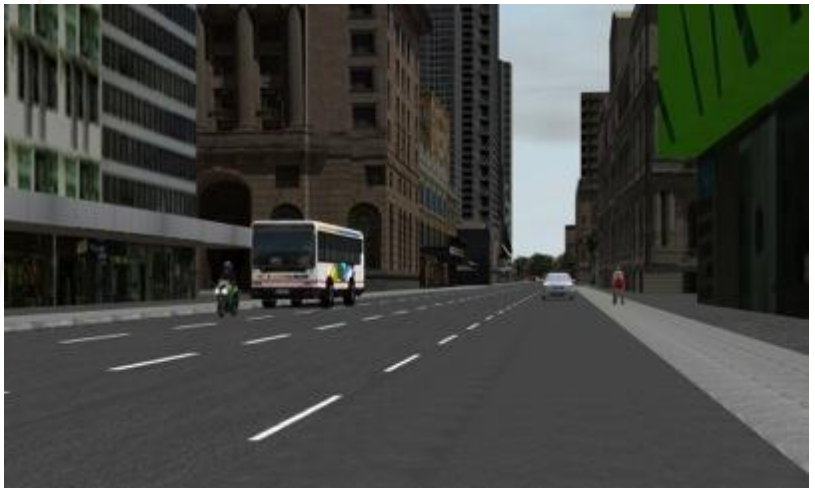
- What is the best way to guide participants through the simulated road network?
- Should seem natural to the driver so as not to influence driver behaviour
- Methods that we have used and that are effective are:
  - voice instructions ("GPS like")
  - road signage
  - both voice and signage at the same time has proved most effective

Managing research participants (4)

- Guidance can also be used to influence driver behaviour:
  - which lane to use
  - what speed to be using
- Voice commands are effective, but some drivers report feeling of being controlled
- Road signage (eg speed limit signs) can be included as frequently as desired and are more natural, but can be overlooked
- Some studies are using custom signs for specific tasks

Completed and planned projects

- Monotony
- Whiplash
- Railway crossings
- Prescription drugs
- ITS eco-driving
- Vulnerable road users
- Brain Computer Interface (BCI)
- Driver aggression



Limitations of driving simulators

- Driver's motivation
- Level of perceived risk
- Simulator sickness
- Vehicle handling
- Validity and generalizability?
- No "Swiss knife" simulator
- **. . . but still a valuable tool for road safety research**

Conclusion

- The Advanced Driving Simulator is proving an effective tool for a range of research studies
- With experience in operation, the issues of simulator sickness and the best way to manage research participants is being refined
- Most drivers become well immersed in the simulation, as indicated by these anecdotes:
  - one participant felt that they could not stop their simulated drive without driving back to the starting point
  - one participant started to become anxious that they were holding up following (simulated) traffic
  - one participant verbally abused the driver of the computer controlled vehicle in front of him

Acknowledgements

Australian Government
Australian Research Council

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

Queensland Government

HOLDEN

United Nations Decade of Action

- UN Decade of Action for road safety launched in May 2011
- Aim is to reduce global road fatalities by 50%

Questions?

T2013 International Conference 26-29 August 2013
Brisbane, Queensland, Australia

Mark your Diaries!

International Council on Alcohol, Drugs and Traffic Safety Conference (T2013)
26-29 August 2013, Brisbane